Sub-Kelvin Detectors

- Use ~meV quanta to obtain better energy resolution than conventional technologies
  - phonons, superconducting quasiparticles
- Can combine with conventional technologies to enable nuclear-recoil discrimination
  - critical for coherent neutrino scattering, WIMP dark matter searches
- Typically not subject to quenching
  - (not mentioned; to be noted in next revision)
  - Same energy scale for EM interactions, alphas, neutrons
- Discussion of general principles and specific implementations for
  - thermal phonon detection
  - athermal phonon detection
  - superconducting quasiparticle detection
  - ionization collection at low temperatures in semiconductors
    - very different from 77K and 300K!
  - scintillation collection at low temperatures

- Large chart with current performances
  - unlike conventional detectors, so many varieties of implementation that generic quantitative results are hard to find
- Will attempt to keep up to date (with much help from individual groups)

Experiment	technique	substrate + mass	sensor	ΔE_{FWHM} at $E=0$	[keV] at E_0	E_0 [keV]	comments
WIMP dark matter							
CDMS I (1996-2000)	thermal phonon, ionization	Ge 0.16 kg	NTD Ge thermistor, H-a-Si/Al electrode	0.3 0.9	0.7 1.1	12 10.4	nuclear recoil discrimination w/ ionization yield
CDMS II (2001-2008)	athermal phonon, ionization	Ge 0.25 kg	tungsten TES, a-Si/Al electrode	0.4 0.7	2.4 0.8	20.7 10.4	CDMS I+ surface-event discrimination w/phonons
SuperCDMS-SNOLAB, in development	athermal phonon, ionization	Ge 0.64 kg	tungsten TES, a-Si/Al interdig.	0.4 0.7	N/A N/A	N/A N/A	CDMS II+ surface-event discr. w/ioniz.+ phonon z asym.
EDELWEISS I (1996-2005)	thermal phonon, ionization	Ge 0.32 kg	NTD Ge thermistor, a-Si/Al a-Ge/Al	2.3 1.1	2.3 1.1	24.2 10.4	nuclear recoil discrimination w/ionization yield
EDELWEISS II (2006-)	thermal phonon, ionization	Ge 0.4 kg	NTD Ge thermistor, a-Si/Al interdig.	3.6 1.0	3.6 1.0	38.0 10.4	EDELWEISS I +surface-event discrimination w/ioniz. asym.
CRESST I (1996-2002)	athermal phonon	Al_2O_3 0.26 kg	tungsten SPT	0.20	0.24	1.5	no NR discr.
CRESST II (2003-)	athermal phonon, scint.	$CaWO_4$ 0.3 kg ($ZnWO_4$)	tungsten SPT (target and photon abs.)	0.3 1.0	0.3 3.5	8.1 10	NR discr. w/scint. yield
α decay							
ROSEBUD (1996–)	athermal phonon, scintillation	BGO 46 g	NTD Ge thermistor (target & photon abs.)	6 N/A	5500 N/A	18 N/A	α discr. w/scint. yield, first detection of ^{209}Bi α decay
β decay							
Oxford ^{63}Ni (1994-1995)	athermal phonon	InSb 3.3 g	Al STJ	1.24	1.24	67	
MARE (2009-)	thermal phonon	$AgReO_4$ 0.5 mg	P-implanted Si thermistor	N/A	0.033	2.6	
$0\nu\beta\beta$ decay							
CUORE (2003-)	thermal phonon	TeO_2* 0.75 kg	NTD Ge thermistor	N/A	7	2527	

* The CUORE energy resolution is worse than can be obtained with Ge diode detectors.